David Sang

Silent flight

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sound
noise
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Aircraft noise has been reduced considerably over the last 50 years. However, people living near airports still suffer greatly from noise; there are protests when new airports, runways and extended flying hours are proposed. And yet most people want the opportunity to fly. The Silent Aircraft Initiative set out to design a much quieter aircraft. Here we describe the results of this project.

Taking the initiative

The Silent Aircraft Initiative is a collaboration between scientists and engineers at two universities, Cambridge (UK) and the Massachusetts Institute of Technology (USA). Professor Ann Dowling of Cambridge University explained its aim.

With air travel predicted to double in the next 20 years, the Silent Aircraft Initiative was launched to address the problem of reducing noise pollution. The result of our work would be a greener, quieter aircraft.

We have worked with many companies in the civil aviation industry to create the design we have today.

The target was to design an aircraft whose noise level would not exceed 63dB (decibels) outside the airport perimeter – that's 25 dB less than today's level, and comparable to everyday background noise in an urban environment. Because of the way the decibel scale works, the aim represented a reduction to just 0.3% of current figures (see Box 1).

The project has come up with a design, the SAX40, which is predicted to do this and which, perhaps surprisingly, has another green benefit – it consumes less fuel than conventional aircraft.

Noise annoys

Aircraft are noisy while both taking off and landing. The affected areas are called the arrival and departure footprints. Together, they cover about 10 km^2.

Noise is unwanted sound, and sound is vibrations in the air. How does an aircraft produce sound?

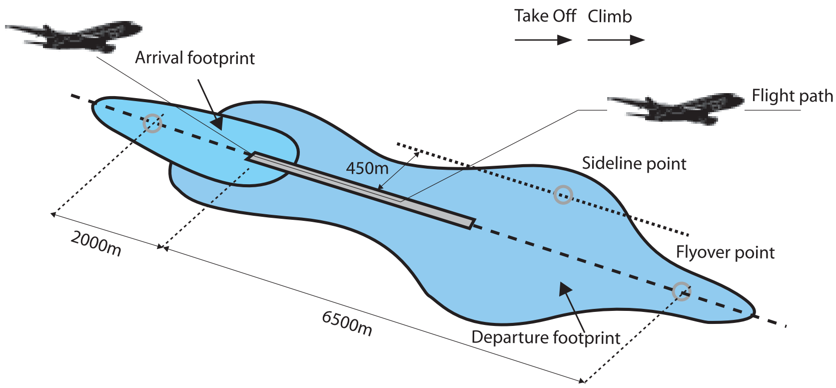
The target

215 passengers

cruising speed Mach 0.8 (230 m/s)

range 9000 km

noise level 63 dB at airport perimeter



Most modern aircraft use jet engines (see Box 2). There are two sources of noise from a jet engine:

- the fan at the front (these are the blades which you may have seen rotating at the front of the engine, and which suck air into it);
- the propulsive jet at the back which pushes out hot gases at high speed to propel the aircraft forwards.

These are the main contributors to aircraft noise on take-off. On landing, there is another source:

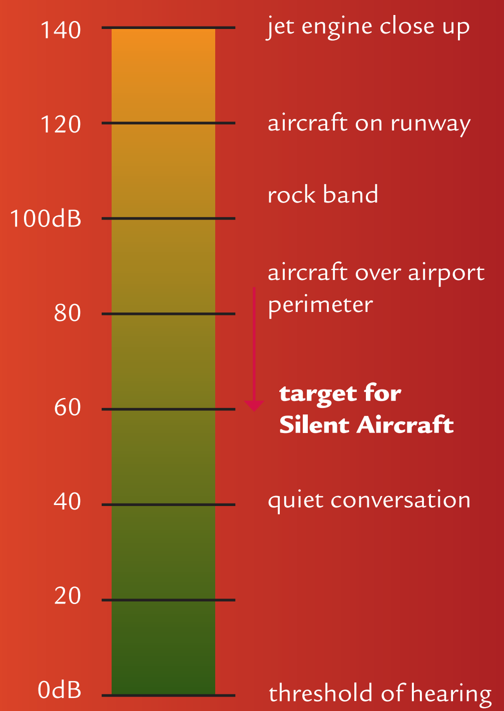
- the aircraft has its landing gear down and wing flaps extended to reduce speed; the flow of air around these structures is very turbulent and this produces more noise.

So the challenge of the Silent Aircraft Initiative was to tackle each of these sources of noise.

Box 1
Sound scales

The decibel scale of sound measurement takes account of the fact that our ears can hear sounds with a great range of loudnesses. The faintest sound we can hear is the zero of the scale, 0 dB. Each 10 dB step up the scale corresponds to an increase in energy by a factor of 10. So 50 dB is 10 times as energetic as 40 dB. This is called a logarithmic scale.

Our ears are very sensitive to sound energy – the threshold of hearing, 0 dB, corresponds to 10-12 joules of energy falling on 1 m2 each second, or less than 10-16 J on your eardrum.



Shaping up

The design of the new SAX40 aircraft is striking. It is a single flying wing, also known as a Blended-Wing-Body (BWB). This shape of airframe has several advantages.

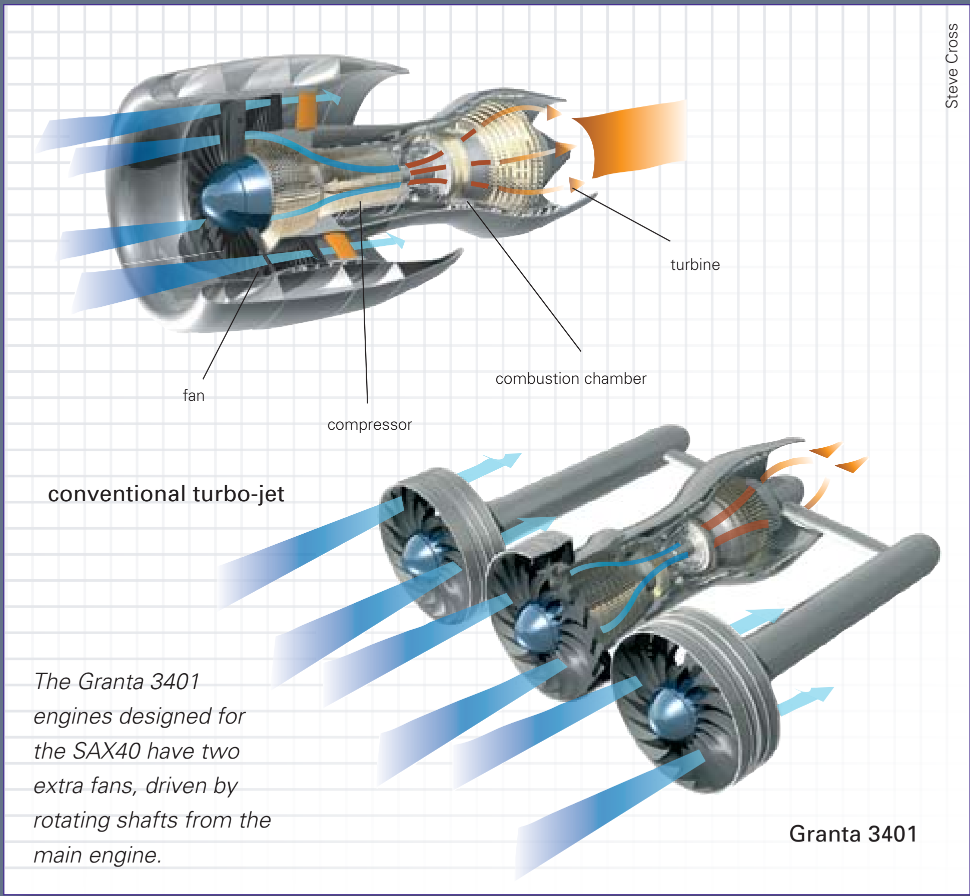
In a conventional aircraft, the wings provide the lift needed to take the aircraft off the ground. In a BWB design, the body is also shaped to give lift. This helps to reduce fuel consumption.

For noise reduction, the engines can be mounted on top of the airframe. Noise coming forward from the fans at the front of the engines is shielded from listeners on the ground; some is reflected upwards.

The design also allows the aircraft to approach the landing runway at a slower speed (less noise from the airframe), and at a steeper angle of descent (again, reducing the noise level at the airport perimeter).

The design has no flaps or slats to control its speed and lift; instead, the leading edges of the wings are designed to droop for landing. The ends of the wings are tipped up, reducing turbulent air flow.

	passenger miles per UK gallon
SAX-40	~149
Toyota Prius hybrid car	~144 with 2 people
Boeing 777	103-121
Boeing 707	55-70



The Granta 3401 engines designed for the SAX40 have two extra fans, driven by rotating shafts from the main engine.

Box 2
Jet engines

Jet engines provide the thrust needed to make an aircraft move forwards. They do this in two ways:

Fuel and air are burned together in the combustion chamber. The hot exhaust gases push out of the nozzle at the back, creating thrust.

On the way, they turn a turbine, which turns the fan at the front of the engine. This sucks air into the engine. Some of it is compressed into the combustion chamber, but some passes around the outside of the engine and out of the back, creating more thrust.

Engine design

The engines designed for the SAX40 are novel. There are three, and each has three fans driven by a central core (see Box 2). Engines like this would produce enormous amounts of drag if they were hung below the wings, but the shape fits well into the airframe so that there is little air resistance. Because the three fans are relatively small, they can spin more rapidly and this gives higher frequency noise which is more easily absorbed. Also, the engines suck in the air which is passing closely over the aircraft body – this air would normally create a wake and hence drag on the aircraft.

A conventional jet engine is noisy, but the source of the noise is actually several metres *behind* the engine, where air turbulence is greatest. This makes it very difficult to deal with. The engines of the SAX40 are different. They have long outlet ducts which are lined with acoustic absorbing materials. The engines also have variable-area exit nozzles. These can be constantly adjusted to give low noise on take-off and maximum fuel efficiency when the aircraft is cruising.

Will it ever fly?

The SAX40 is simply a design. The various engineering ideas which have been built into it have been tested using computer software, and simulations show that the desired reduction in noise can be achieved. They also show that the aircraft will be more fuel-efficient than current models, achieving 149 passenger-miles per gallon of fuel (comparable to today's best cars).

However, technological challenges remain. For example, are there materials strong enough to build the aircraft? Ann Dowling explains the tasks that remain:

The SAX40 is very much a work in progress. Composite structures are increasingly used in 'tube-and-wing' aircraft, so it is feasible that strong enough composites will exist in the future.

Several PhD students from the team at Cambridge are still working on details of the design, and we are meeting NASA soon to discuss the next stage.

The target is a quieter, greener passenger aircraft by 2030. Watch this (aero)space.

David Sang is an editor of Catalyst. *Thanks to Prof. Ann Dowling of Cambridge University for help with this article.*

Look here!

The Silent Aircraft Initiative is at **www.silentaircraft.org**

Greener by Design, a sustainable aviation group: **www.greenerbydesign.org.uk**

More about how jet engines work: **www.rolls-royce.com/education/schools/how_things_work**